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The Tomato Fruit Worm in Tennessee

University of Tennessee Agricultural Experiment Station

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THE UNIVERSITY OF TENNESSEE
AGRICULTURAL EXPERIMENT STATION

BULLETIN No. 174.

JANUARY, 1941

THE TOMATO FRUIT WORM
IN TENNESSEE

By

S. MARCOVITCH and W. W. STANLEY



Tomatoes with larvae of tomato fruit worm feeding in them.
(About $\frac{1}{2}$ natural size).

KNOXVILLE, TENNESSEE

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THE TOMATO FRUIT WORM IN TENNESSEE

By

S. MARCOVITCH and W. W. STANLEY

INTRODUCTION

The most important insect pest of the tomato in Tennessee is the tomato fruit worm, *Heliothis armigera* Hbn. Taking into account its depredations on corn and other crops, it may be considered the most important of all insect pests in the State. Entomologists estimate that it does 100,000,000 dollars' damage in the United States each year. Its distribution is world-wide.

In response to numerous inquiries, the Agricultural Experiment Station, in 1937, formulated a project for the study of the tomato fruit worm. This bulletin discusses the various phases of the study, including trials of light traps, parasites, sprays and dusts, poison baits, and the use of corn as a trap crop.

LOSSES

The tomato fruit worm attacks the early spring crop of tomatoes, which bring the best price. Worms are most numerous in West Tennessee. In 1921, Gibson County suffered an almost total loss of its tomato crop; the damage was estimated at over \$250,000. Of all states, Tennessee ranks tenth in tomato production. The area devoted to the crop in this State in 1934 was about 20,534 acres. Generally from 10 to 100 percent of the early crop is infested. In some cases tomatoes which appear sound when shipped decay in transit because of the presence of worms inside the fruits. Wilcox and Stone (17) estimate that the tomato fruit worm causes an annual loss of \$2,600,000 to the tomato crop in the United States.

FOOD PLANTS

Heliothis armigera is one of the most omnivorous insects known. Primarily it is a seed eater. The host plants are numerous and varied, according to Phillips and King (14). These include corn, cotton, okra, beans, tomatoes, peanuts, vetch, peas, alfalfa, cowpeas, cucumber, castor beans, squash, melons, tobacco, asparagus, cabbage, pepper, sunflower, beggarweed, Jimson weed, ground cherry, hemp, morning-glory, gladiolus, mallow, poppy, peach, *Sida spinosa*, and crabgrass. Corn is the preferred food; generally as long as corn lasts other cultivated crops escape. When corn is not available, early crops, such as the tomato, or late crops such as beans, will suffer. Sweet corn is preferred to field corn, and in the South, worms are the limiting factor in its production. In recent years the fruit worm has become an important pest on late lima beans grown for canneries.

DESCRIPTION OF INJURY ON TOMATO

Upon hatching from the eggs laid on the leaves, the tiny larvae feed for a short time on the tender foliage (figure 1). When numerous, the worms sometimes will be found boring within the stems.

The larvae wander about and, coming upon a tomato, proceed to enter it, usually at the stem end. When small they produce injury that can hardly be detected from the outside. The entrance burrow soon heals over, but it leaves a tell-tale mark, as if the tomato had been stung. When the worms are larger, they make their characteristic burrows (figure 2). The holes vary from the size of a pinhead to $\frac{3}{4}$ inch in diameter. Decay usually sets in, and the fruit often becomes unsightly and falls to the ground. Because of the wandering habit of the larvae, one worm may injure several tomatoes in a cluster.

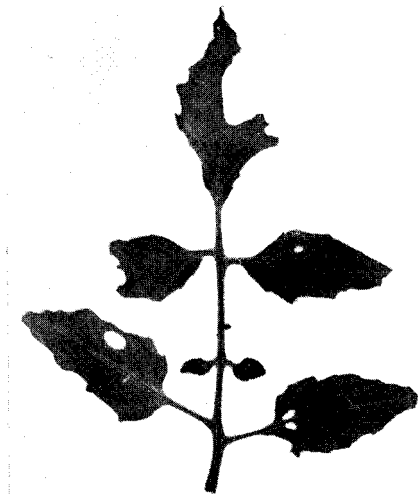


Fig. 1—Tomato leaves, showing injury by the tomato fruit worm.

SEASONAL HISTORY

In Tennessee, early tomato plants are set in the field from about the 10th to 25th of April. A month later, when fruits begin to set,



Fig. 2—Injury to fruit, caused by the tomato fruit worm.

close observation will reveal the first deposition of eggs on the leaves (figure 3). In 1931, eggs were found as early as May 15. The eggs

hatch in about 5 days. In late May or early June the small worms may be found on the leaves and in the small fruits.



Fig. 3—Egg of the tomato fruit worm.
(Enlarged about 4 times).

In 1922, a considerable number of worms and of injured fruits were found in tomato fields at Jackson on June 5. Many of the largest tomatoes were 2 inches in diameter. Some of the growers began spraying with lead arsenate May 19 because of the early season. Sweet corn was observed to be in silk at the Jackson Station June 5. A few ears contained full-grown larvae.

The worms become full-grown in from 2 to 4 weeks, depending on temperature, and enter the ground for pupation. The pupa stage

(figure 4) also lasts from 2 to 4 weeks, and at its completion the moths emerge (figure 5). Egg laying begins soon after emergence. Each female moth is capable of depositing from 500 to 3000 eggs. Worms that hatch in the fall do not emerge, but pass the winter as pupae in the ground. Several generations are produced in a single season; no observations were

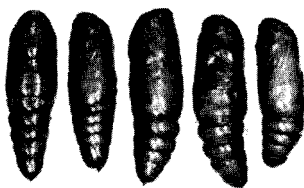


Fig. 4—Pupae of the tomato fruit worm.

made as to the exact number, but possibly 4 or 5.

MOTH FLIGHTS

From 1928 to 1934, light traps were operated to determine seasonal abundance of the moths. Records were obtained from a trap

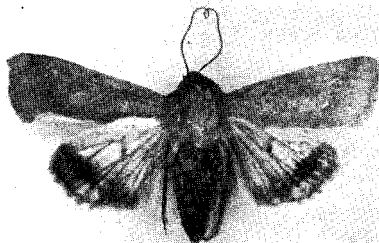


Fig. 5—Moth of the tomato fruit worm.

on top of Morgan Hall, about 75 feet high. This trap consisted of a bucket fitted with a funnel and a 100-watt lamp attached above it.

The earliest date of capture was May 2. That was in 1932. In 1931, moths were not caught until June 5. Flight continues through the summer and late fall; adults were caught on warm nights as late as December 11. The number of moths caught at any one time was never large. The maximum number for a single night was 21, on October 1, 1934. The catches in May, June, and July are only 1 or 2 per night. The largest number of moths were caught in August and September, as shown in table 1.

From August 6 to August 28, 1935, light traps were operated in a tomato patch and in a plot of field corn which began to silk about August 1. Only 2 adults were caught in each location. From August 30 to September 24 one trap was operated in a tomato patch and another in a piece of fallowed ground. Only 6 moths were caught in each location.

TABLE I—Summary of moth flights as recorded by light trap, on top of Morgan Hall, beginning in April.

	1928	1929	1930	1931	1932	1933	1934
First catch		May 29	May 16	June 5	May 2	May 23	May 4
Last catch	Nov. 6	Oct. 12	Nov. 21	Dec. 11	Oct. 7	Oct. 24	Oct. 25
Maximum catch	Sept. 20	Aug. 28	Aug. 19	Sept. 2	Sept. 7	Sept. 20	Oct. 1
Number nights operated each season	58	96	111	78	121	100	67
Number nights specimens caught each season	41	35	62	58	65	55	46
Average number moths caught per night	3.5	1.1	2.1	3.3	2.0	2.6	3.7

NATURAL ENEMIES

The tomato fruit worm has many natural enemies, which help to keep it in check. One of the most interesting is a tiny egg parasite known as *Trichogramma minutum*. This parasite is rarely found early in the year, but as the season advances it becomes more numerous.

Several releases were made in tomato fields during the seasons 1931-33 in order to test its efficiency. Four thousand parasites per acre were scattered over the tomatoes when the first eggs were found, and about the same number every week thereafter for 4 weeks. Results were disappointing. *Trichogramma* is hampered by its small size—it cannot find an egg that is more than a quarter-inch away. The eggs of its host are laid singly, and this adds to the difficulty in finding them. Barber (2) observes that *Trichogramma* appears to work efficiently only when its host is abundant.

Another small insect, *Triphleps insidiosus*, is valuable as a predator on the eggs of the corn ear worm, but is of little value for tomatoes because it does not become abundant until late in the season.

Several other insects feed on the eggs; among them, two ladybird beetles, *Hippodamia convergens* and *Megilla maculata*. These have been observed on tomatoes and corn.

As many as 52 eggs have been found on a single ear of corn. Yet as a rule only one larva develops, because of the cannibalistic habit of the worms. The same is true when eggs are laid on tomatoes. Were it not for this fact the fruit worm would be a worse pest than it is.

Phillips and King (14) report other natural enemies, such as larvae of lace-winged flies, ants, spiders, certain diptera, hymenoptera, and birds.

EXPERIMENTAL CORN AS A TRAP CROP

Because sweet corn is the preferred host, practically all recommendations mention the use of corn as a trap crop for control of the tomato worm. Since there was no experimental evidence of the value of corn for this purpose, the question was given special attention, in 1923 and 1924, by Marcovitch and Robert (11) in tests at Jackson.

To have the corn in close proximity to the tomatoes, plot 1 was planted with early corn, a hill alternating with each tomato plant. A second plot included corn in alternate rows with tomatoes. In other plots the proportion of corn was successively reduced until the last plot had only 1 row of corn for every 8 rows of tomatoes. One plot had no corn and was used as a check.

A count made on June 21 showed that plot 1 had 66 wormy tomatoes, and the check plot only 19. The plots with less corn had proportionately fewer wormy tomatoes. These tests proved that corn planted among tomatoes does more harm than good. The corn attracted the moths, and many of them laid their eggs on the tomatoes. No tests were carried out to determine the value to tomatoes of patches of corn in adjacent fields. A few observations indicated that a cornfield 100 feet away might have afforded some protection to the tomatoes.

LIGHT TRAPS

Since moths are attracted to lights, claims are made periodically as to the value of light traps. A trap of the electrocutor type with a 100-watt clear lamp was furnished by the Tennessee Valley Authority for experimental tests with sweet corn. Beginning a week before tasseling and continuing until harvest, the trap was operated in the center of a plot at a height of 8 feet. Examination of silks revealed eggs within a few feet of the trap, indicating that it failed to afford material protection against the worms. Data on infested ears likewise showed negative results. The same was true of tests in tomato fields.

INSECTICIDAL TESTS

Since a related insect, the tobacco budworm, is readily controlled by a poisoned bait composed of 1 part of lead arsenate and 75 parts of corn meal, it was thought possible that a bait would be effective against the tomato fruit worm. Beginning in 1936, baits of cottonseed meal and corn meal containing cryolite¹ or sodium fluosilicate were used as control measures on tomatoes. Along with these treat-

¹Synthetic Alorco cryolite was used in all tests.

ments, sprays of lead arsenate and cryolite, and a proprietary dust containing derris and sulphur, were used. Each treatment was applied 3 times. Examination of the ripe fruit showed that the derris-sulphur dust was not effective. Good control was obtained with the baits and with cryolite and lead arsenate sprays.

In 1937, baits and sprays were tested again at the Experiment Station at Knoxville. Sprays were applied at the rate of 350 gallons per acre with a 10-gallon hand pump operating at about 100-pounds pressure. Dusts were applied with a rotary hand duster at the rate of 15 pounds to the acre. Baits were broadcast by hand at the rate of about 75 pounds per acre, care being taken that the tops of all the fruit clusters were covered. Applications were made June 11, 23, and 30, and July 6.

Tomatoes were harvested as they ripened and records were kept of sound fruit and wormy fruit. The results are presented in table 2.

TABLE 2—*Tomato fruit worm experiments, 1937. Tomatoes harvested from June 19 to July 13.*

Treatment ¹	Rate of application per acre	Tomatoes examined	Tomatoes wormy
BAIT	Pounds	Number	Percent
Cottonseed meal plus 10% cryolite	75	648	29
DUST			
36% cryolite	20	824	56
SPRAYS	Gallons		
Cryolite, 3 lbs. to 100 gals.	350	801	41
Calcium arsenate, 3 lbs. to 100 gals.	350	670	46

¹Each treatment applied on 1/31 of an acre.

Best results were obtained with the bait. Sprays were not very effective; and the dust, containing 36-percent cryolite, was much less effective. Other tests were conducted, with sodium fluosilicate and

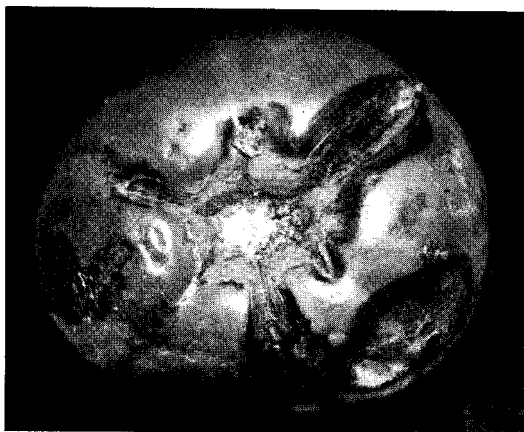


Fig. 6—Tomato injured by lead arsenate used in bait form.

calcium arsenate in baits. The sodium fluosilicate burned the foliage, and calcium arsenate injured the fruit.

During the seasons of 1938 and 1939 the tomato fruit worm infestation was so low that no conclusive data could be obtained. Observations on the effects of the sprays and baits on the fruit showed that lead arsenate was causing considerable fruit injury, particularly when used as a bait (figure 6).

In 1940, a severe infestation developed. The worms were even found boring into the stems. This type of injury was reported by many growers in East Tennessee.

For the experiments in 1940 a block of 320 tomato plants was used in such a manner that each of the 8 treatments was replicated 4 times. Data for each treatment were collected on a total of 40 plants, in 5 plant units. The insecticide applications were made on June 5, 20, and 29. The ripe fruit was harvested from July 1 to July 24, and the percentage of wormy tomatoes was recorded. The data from this experiment are summarized in table 3.

TABLE 3—*Tomato fruit worm experiments, 1940. Tomatoes harvested from July 1 to July 24.*

Treatment	Rate of application per acre	Tomatoes wormy ¹
BAITS		
Corn meal plus 4% cryolite	Pounds 40	Percent 9.1
Cottonseed meal plus 10% lead arsenate	50	11.2
Cottonseed meal plus 10% cryolite	50	15.7
SPRAYS		
Cryolite, 6 lbs. to 100 gals.	Gallons 180	22.0
Lead arsenate, 6 lbs. to 100 gals.	180	21.0
Cryolite, 6 lbs. and copper "34", 6 lbs., to 100 gals.	180	31.0
Copper "34", 6 lbs. to 100 gals.	180	41.9
Check— not treated		47.8

¹Analysis of data shows an error of 5.5 percent.

The untreated plots showed 47 percent wormy fruit. Baits were more effective than sprays, reducing the injury to 9 percent. While lead arsenate bait gave excellent control, it produced considerable injury to the fruit (figure 6). Injury was observed also from the lead arsenate sprays. There was no injury to the tomatoes by cryolite bait or spray. Copper "34" when used with cryolite materially reduced the control of worms.

The bait method has the advantage of being simple and inexpensive and requiring no machinery. Because Tennessee tomatoes generally are staked, power machinery cannot be made use of readily. Hand sprayers also have certain disadvantages.

Other investigators have tried cryolite and found it effective for the tomato fruit worm. Michelbacher and Essig (13) obtained good results with a 40-percent cryolite dust in California. In 1938, 5000 acres were dusted with cryolite in that state.

Based on the work in California, White (16) recommends a 70-percent cryolite dust diluted with 30-percent talc. Of this dust mixture, 10 pounds is used in the first application, 20 in the second, and 30

in the third, at intervals of 2 weeks.

In Washington, Webster (15) reported that among various treatments tried, a dust consisting of equal parts of cryolite and talc gave the best results, yielding practically a clean crop of tomatoes. Corn meal with cryolite was less effective.

Wilcox and Stone (17), in southern California, tried a large number of insecticides, including calcium arsenate, cryolite, cuprous cyanide, and phenothiazine. Results from 523 field plots of tomatoes treated for control of the fruit worm showed the most promising treatment to be a 50-percent cryolite dust with talc as the diluent. Good results were obtained with a bait made up of 25 pounds of corn meal and 1 pound of cryolite. Three applications of this bait were made—the first when the plants had a spread of about 1 foot, the others following at intervals of 2 weeks.

SPRAY RESIDUES

In Tennessee no analyses were made for spray residues. In California, where it is necessary to dust the tomato fields during harvest, Michelbacher and Essig (13) gave this problem considerable attention. They made analyses for fluorine and arsenical residues. Tomatoes dusted with cryolite showed residues ranging from .025 to .106 grain of fluorine per pound of fruit. When the fruit was passed through the regular cannery washer, the quantity of residue was reduced to well below the 1938 legal tolerance of .01 grain. For the green market, washing or wiping was advised.

In 1939 the tolerance on fluorine was raised to .02 grain per pound of fruit. Marcovitch (12) made a study of the toxicity of cryolite to animals, and concluded that there is no danger to human health from cryolite spray residues. The early work on fluorine showed that 3 parts per million of fluorine in the water of Arizona when used for drinking and cooking was capable of producing mottled enamel on the teeth. The tolerance of .01 grain was placed on fluorine residues because of this supposed toxicity of fluorine in water and not from evidence obtained from sprayed food. Our spray residues are composed of powders more or less insoluble. In a series of tests, Marcovitch (12) showed that fluorine in a water supply is much more toxic than fluorine in powdered form. This is because water used for cooking concentrates the fluorine. In addition, water is consumed in greater quantity than all other foods ingested and may amount to 30 times the quantity of sprayed food.

Marine foods, such as salmon, sardines, and baby foods prepared with bone meal, contain up to 12 parts per million of fluorine; yet mottled enamel has been produced by no other means in the United States than the continued ingestion of water containing toxic amounts of dissolved fluorides during the period of calcification of the crowns of the permanent teeth. The present tolerance, therefore, is a standard for water supplies that has no relation to cryolite spray residues.

The presence of arsenicals on the farm has caused human fatali-

ties when swallowed accidentally. This can not happen with cryolite; no one has ever been reported to have died from cryolite. Cryolite fed to rats in the equivalent of $1\frac{1}{2}$ pounds per person in a single dose caused no mortality. On this basis cryolite does not need a poison label, for a poison is any material that is capable of causing fatalities in amounts of 60 grains, or about $\frac{1}{2}$ teaspoonful.

From 1932 until recently, the toxicity of fluorine has been emphasized with little regard for the possible useful qualities of fluorine in nutrition. In the past two years a considerable amount of evidence has appeared that fluorine may have most important tooth-preservative qualities.

As is well known, fluorine is found in greatest amounts in the teeth and bones of animals. Armstrong and Brekhuis (1) analyzed sound and carious teeth and found the fluorine content of the former to be 111 parts per million, as compared with 69 for the latter. Dean (8) made a study of dental caries in a mottled-enamel area and in a nearby section without mottled enamel, and showed a reduced incidence of decay in the mottled-enamel area.

Hodge and Finn (9) fed a group of 90 rats a caries-producing diet of coarsely ground corn. A second group on the same diet had their teeth bathed in a weak solution of potassium fluoride once a day. Results of this and other experiments show that high levels of fluoride in the diet greatly reduce the incidence of caries, indicating the possible usefulness of fluorides in the prevention of tooth decay. The activities of caries-producing organisms have been shown by Bibby, cited by Cox (6), to be definitely reduced.

No attempt will be made to cite all the references, as a review of the subject has been presented by Cox (6). Enough data have already accumulated to show the beneficial effects of fluorine in the prevention of tooth decay. If there is a deficiency of fluorine in the diet at the time of the formation of enamel, the caries resistance of the teeth is greatly lowered. The Buhl Foundation (3) urges that consideration be given to the possibility of the mass reduction of dental-caries incidence by control of the fluorine content of the water supplies. This would insure the desired constant amount of fluorine. The fluorine in food is variable. Only about $\frac{1}{2}$ milligram is obtained in the food supply. It appears that about 4 milligrams per day is essential for sound teeth. Of all races in the world, Eskimos have the best teeth—and they consume ground bones that are high in fluorine. Our present refined diets are low in fluorine. We may even come to the stage at which fluorine-sprayed fruits will be considered desirable for making up deficiencies.

RECOMMENDATIONS FOR CONTROL

BAITS

Under Tennessee conditions, best results in control of the tomato fruit worm were obtained with a bait composed of cottonseed meal or corn meal and cryolite. The bait method has the advantage of being

inexpensive and requiring no machinery (figure 7). The following bait is advised for one acre:

Corn meal or cottonseed meal	50 pounds
Cryolite	5 "



Fig. 7.—Applying cryolite bait for control of the tomato fruit worm.
This method is inexpensive and requires no machinery.

The two materials are put into a drum or tight container and rotated. After being thoroughly mixed, the bait may be put into a bucket and a pinch or two applied to the fruit clusters and nearby leaves (figure 8). Generally it will take from 40 to 60 pounds of bait per acre, depending on the size of the vines. From 3 to 5 applications at 10-day intervals will be required according to the severity of infestation and amount of rainfall. For best results, the bait must be on the vines by the time the first fruits are the size of small peas. Once the worms are in the tomato, they are not generally attracted to the bait.

SPRAYS

For those growers who wish to spray, and have the necessary equipment, the following spray is recommended:

Cryolite	3 pounds
Water	50 gallons

The vines should be thoroughly covered with the spray material. As in the case of baits, from 3 to 5 applications should be made at intervals, beginning at the time the first fruits set.

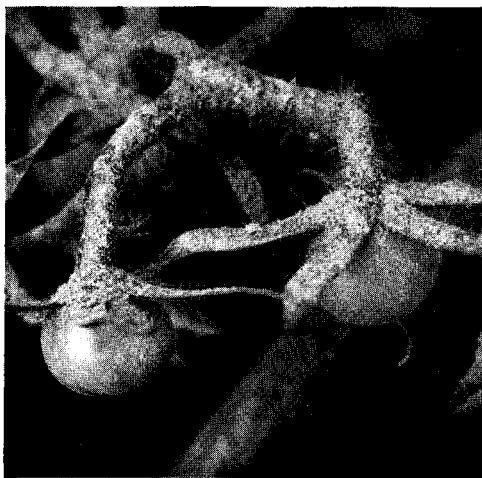


Fig. 8—Small tomatoes, in the right stage for the first application of bait.

DUSTS

Our work indicates that dusts are not as affective as baits or sprays. Under the dry conditions of California, however, good results have been reported by White (16) with the following cryolite dust:

Cryolite	70 parts
Talc	30 "

From 10 to 30 pounds of the dust mixture was used, according to size of vines.

CONTROL ON LIMA BEANS

Next to corn and tomatoes, lima beans probably suffer most from the fruit worm in Tennessee. In 1936, several hundred acres of limas grown for canneries in Monroe County were almost completely destroyed. That year, because few bean beetles were present, the vines were not sprayed.

As in the case of tomatoes, eggs are deposited on the blossom clusters and leaves. Upon hatching, the small worms feed for a time on the leaves, and then migrate to the flower stalks and developing pods. When the worms are about half grown, they begin boring into the pods and eat the small beans within. The depredations are easily recognized by the round entrance holes (figure 9).

In 1936, in Monroe County, the worms were so abundant and worked so fast that growers had neither time nor sprayers sufficient to cope with the situation. Several baits were broadcast over the fields to determine whether it was possible to check the worms with-

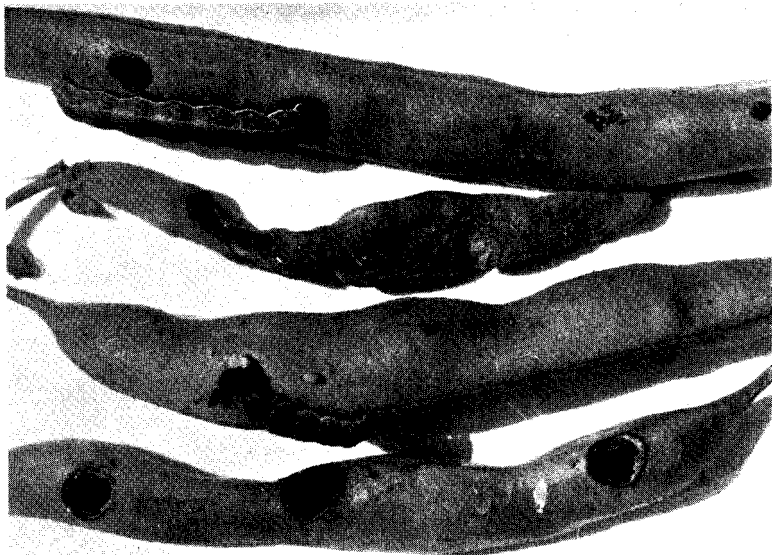


Fig. 9—Corn ear worm larvae boring into pods of bunch beans.
This same type of injury is produced on lima beans.

out the use of machinery. Fourteen different treatments, including several sprays and dusts of magnesium arsenate, rotenone, pyrethrum, and cryolite, were also tested. Best results were secured from a bait consisting of cottonseed meal and 5-percent sodium fluosilicate, used at the rate of 100 pounds to the acre. Marcovitch (10) found sprays and dusts of little value against large worms.

This pest is very destructive of lima beans on the eastern shore of Virginia. There Brannon (4) found that among the various materials tried out, such as derris, pyrethrum, nicotine, cuprous cyanide, barium fluosilicate, and phenothiazine, best control was obtained from cryolite both as spray and dust. Cryolite spray was used at the rate of 3 pounds to 50 gallons of water. The dust was composed of 60 parts cryolite and 40 parts talc or sulfur. Brannon advises 3 or 4 treatments, beginning about the time the beans come into bloom.

In 1939, the Tennessee Station carried out additional tests in Monroe County on lima beans grown for canning. Several materials were tried, including magnesium arsenate, rotenone, and cryolite sprays and baits. Four applications were made, on August 15 and 25 and September 5 and 12. Each treatment, covering $1/36$ of an acre, was replicated 4 times. Table 4 shows the materials used, amounts of water, and other data.

On September 15, three days after the last application of materials, infestation records were obtained. Plants were jarred, and the

TABLE 4—Results of treatments on lima beans for canning in Monroe County, Tennessee, 1939.

Treatment	Rate of application per acre	Larvae per plant Sept. 15	Average weight of pods Sept. 25
	Gallons	Number	Ounces
Magnesium arsenate, 5-100 ; lime, 7½-100	150	1.37	197.3
Rotenone 5%, 2½-100	150	1.29	195.0
Check	None	1.35	191.0
Natural cryolite, 8-100	150	.52	222.5
Alorco cryolite, 7-100	100	.70	214.5
Alorco cryolite, 8-100	150	.56	238.3
Alorco cryolite, 8½-100	200	.28	232.3
Alorco cryolite 10%, in cottonseed meal85	198.5

larvae fell to the hot ground and soon became active, enabling a count to be made. The data in table 4 show that all the fluorine treatments effectively reduced the number of larvae. Counts were made also on the number of loopers (probably *Autographa brassicae*) present. Plants treated with fluorine sprays had about one-tenth the number of loopers found after the other treatments.

On September 25 the lima beans were at the right stage for canning. Data on yield were obtained by removal of pods from vines and recording of weight in ounces per 100 feet of row. As indicated in table 4, both magnesium arsenate and rotenone were shown to have no effect. The best control was obtained with a cryolite spray—8 pounds to 100 gallons of water—applied at the rate of 150 gallons per acre.

The plot sprayed with cryolite gave a yield of 3,148 pounds of beans per acre, while the unsprayed plot gave a yield of 2,195 pounds. The sprayed beans thus showed a net profit of \$24.75 per acre.

LABORATORY STUDIES WITH INSECTICIDES

In 1936, laboratory studies were conducted on the tomato fruit worm with various baits. These studies showed that cottonseed meal and corn meal were more effective than bran or wheat flour, and that cryolite was as toxic as sodium fluosilicate.

In 1939, field tests showed that magnesium arsenate possessed little toxicity. It was deemed advisable, therefore, to make careful laboratory tests on the relative toxicity of cryolite, magnesium arsenate, and lead arsenate.

Deposits of these materials, ranging from .01 to .27 milligram per square centimeter, were sprayed on tobacco foliage. Larvae of known weights were then placed on tobacco and allowed to feed for an overnight period. The food eaten was recorded in square centimeters, and from this the dose was calculated as milligrams of poison per gram of body weight. The results, as given in table 5, show that magnesium arsenate was practically non-toxic to the tomato fruit worm, even though the worms ate from 3 to 10 times as much as they did of cryolite. A dose of 2.81 mg. of magnesium arsenate per gram of insect killed only 22 percent. Lead arsenate is in about

the same zone of toxicity as cryolite. The failure of magnesium arsenate to kill the tomato fruit worm offers an interesting example of the specificity of insecticides.

To test the toxicity of these materials in corn-meal baits, mixtures of 1 and 4 percent were made and placed with the larvae for an overnight period. The amount consumed was found by weighing the food before and after eating. Here again the cryolite was the most toxic, followed by lead arsenate. Magnesium arsenate failed to kill.

TABLE 5—Summary of toxicity tests on *H. armigera* larvae fed various deposits of cryolite, lead arsenate, and magnesium arsenate on tobacco foliage.

Insecticide	Deposit per sq. cm.	Lar- vae	Average larval weight	Area eaten	Dose	Kill in hours			
						24	48	72	96
	Mg.	Num- ber	Mg.	Sq. cm.	Mg.	Percent	Percent	Percent	Percent
Cryolite	.01	11	173.4	1.97	.11	None	9	9	9
	.03	11	223.2	.48	.07	"	9	9	18
	.08	9	371.6	.50	.11	0	0	0	0
	.12	10	48.3	.13	.32	10	50	70	70
	.17	9	242.2	.11	.08	0	0	0	11
	.23	10	119.3	.09	.17	20	40	50	50
Lead arsenate	.02	17	253.2	.89	.07	0	6	6	24
	.06	7	248.6	.37	.09	0	0	0	0
	.15	5	294.4	.15	.08	0	0	0	0
	.17	10	186.7	.13	.12	30	50	50	60
	.25	10	373.6	.12	.08	40	40	50	50
Magnesium arsenate	.04	11	256.4	4.64	.72	0	0	0	0
	.07	8	251.9	2.73	.08	0	0	0	0
	.09	9	196.1	2.73	1.25	0	0	0	0
	.14	18	167.5	1.45	2.34	0	0	0	0
	.27	9	114.2	1.13	2.67	0	0	0	22

SUMMARY

The tomato fruit worm, *Heliothis armigera*, is the most important insect pest of the tomato in Tennessee. The worms bore into the tomatoes and are capable of destroying 25 percent or more of a crop.

Egg laying starts as soon as the young fruits begin to set—in early seasons, about May 15. The small worms and injured tomatoes usually may be observed in late May or early June.

Many natural enemies are known, among them being an egg parasite, ladybird beetles, and predacious insects. In 1931-33 several thousand egg parasites (*Trichogramma minutum*) per acre were released, but results were negative.

In 1923 and 1924, corn was given extensive trials as a trap crop at the West Tennessee Experiment Station, at Jackson. Where corn was planted among tomatoes, the infestation was increased. The results showed conclusively that corn was more detrimental than helpful.

Light traps of the electrocutor type also gave negative results.

Experimental work with insecticides consisted of baits and sprays with cryolite, lead arsenate, and calcium arsenate.

Best results were obtained with a bait composed of 10-percent cryolite in corn meal or cottonseed meal. Three applications were made, at the rate of 40-60 pounds each per acre. The bait was applied by hand to the fruit clusters.

The sprays of cryolite were used at the rate of 3 pounds to 50 gallons of water, and gave good control.

The use of cryolite baits or sprays is safe on tomatoes and does not offer a residue problem. Evidence is accumulating from various sources that fluorine may have most important tooth-preservative qualities, and that our diet is deficient in fluorine.

On lima beans, cryolite—8 pounds to 150 gallons of water—as a spray gave best control, while magnesium arsenate was of no value. Laboratory tests with magnesium arsenate showed that it possessed practically no toxicity against the tomato worm.

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